VOLUME AND VOLATILITY SURROUNDING QUARTERLY REDESIGNATION OF THE LEAD S&P 500 FUTURES CONTRACT

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During the last weeks before each quarterly expiration of Standard & Poor's (S&P) 500 futures, the bulk of trading volume begins to shift away from the next-to-expire (nearby or lead) contract toward the second-to-expire (next out) contract. At some point, the exchange formally redesignates the next out as the new lead contract, and the next out replaces the nearby in the futures pit location designated for the lead contract. This event invariably results in a dramatic increase (decrease) in trading activity in the next out (nearby) contract. This shift in relative trading volumes is due to the

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microstructure of the futures exchange rather than new information or underlying volatility conditions. The event thus offers us an opportunity to examine how volatility responds to noninformation-based exogenous changes in volume. This study examines the volatility behavior of nearby and next out S&P 500 futures contracts on the 10 days surrounding quarterly redesignation of the lead contract. Our model measures possible changes in (a) the level of volatility and/or (b) the association between volume and volatility after redesignation of the lead contract. Results indicate that when we account for the association between volume and volatility, the higher volume lead contract consistently experiences a lower level of volatility. This outcome supports the view that the larger population of liquidity providers who trade the more active lead contract fosters greater market depth and lower volatility. Jrl Fut Mark 21:1119–1149, 2001

INTRODUCTION

A large body of empirical evidence documents a positive association between volume and volatility in the same time period.[1] However, these studies do not shed any light on whether volume causes or follows movements in volatility. Thus, it is difficult to determine whether market volatility is caused by the arrival of new information or trading itself generates volatility.

Our study addresses this question by analyzing a recurring event that regularly fosters exogenous changes in trading volumes in the market for Standard & Poor's (S&P) 500 futures. The event is quarterly redesignation of the lead S&P 500 futures contract by the Chicago Mercantile Exchange (CME). This event involves the CME announcing a switch in trading locations in the futures pit for the two shortest maturity contracts before each quarterly expiration. The switch is associated with the rolling over of futures positions from the next-to-expire (nearby) contract to the second-to-expire (next out) contract. This quarterly event consistently results in a dramatic increase in volume for the next out contract and a commensurate decline in volume for the nearby contract. The change in relative trading volumes is due to the practicalities of coping with a coming expiration of the nearby contract rather

[1]See, for example, Bessembinder and Seguin (1992); Bessembinder, Chan, and Seguin (1996); Clark (1973); Cornell (1981); Daigler and Wiley (1999); Epps and Epps (1976); Foster (1995); French and Roll (1986); Garcia, Leuthold, and Zapata (1986); Grammatikos and Saunders (1986); Jain and Joh (1988); Karpoff (1987); Kawaller, Koch, and Koch (1990); Kawaller, Koch, and Peterson (1994); Lamoureaux and Poon (1987); Rutledge (1979); Upton and Shannon (1979); and Wood, McInish, and Ord (1985).

than new information or underlying volatility conditions at the time of the event.

We examine whether this exogenous change in relative trading volumes is systematically associated with a change in (a) the level of volatility, (b) the extent of association between volume and volatility, or (c) both. We analyze return volatility for the next out and nearby contracts on the 10 days surrounding the quarterly event. For the next out contract, the move into the lead contract pit position allows us to investigate whether a noninformation-induced increase in trading volume tends to increase or reduce volatility, ceteris paribus. Similarly, we can investigate the effect of a decline in trading volume by assessing volatility behavior of the nearby contract surrounding this event.

Our results indicate that volume and volatility are positively correlated for the nearby and next out contracts, both before and after redesignation of the lead contract. This outcome supports most prior empirical work. However, after controlling for movements in volume, we find that the higher volume associated with the lead contract designation fosters a lower level of volatility, regardless of whether the lead contract happens to be the nearby or next out contract. That is, once we control for the association between volume and volatility, the level of volatility tends to decline for the next out after it becomes the higher volume lead contract, whereas volatility tends to increase for the nearby after it becomes the lower volume nonlead contract.

One possible economic rationale for this inverse relation between noninformation-based changes in liquidity and the level of volatility lies in the composition of traders and the depth of the market for the higher volume lead contract versus the lower volume nonlead contract. For example, Bessembinder and Seguin (1992) suggested that the volume–volatility relation depends on the type of trader predominant in the marketplace. Daigler and Wiley (1999) found that, although trading by the general public is positively related to volatility, trading by clearing members and floor traders (providers of liquidity) is often inversely related to volatility. When the population of market makers shifts its attention to a newly designated lead contract, there is a change in the amount of capital available to service the demand for liquidity in each contract. After redesignation, the depth of the market improves for the next out contract and deteriorates for the nearby contract. The greater market depth associated with the lead contract designation can absorb more of the imbalances between buyers and sellers that result from information-based trading and thus attenuates the level of volatility for the lead contract.

Empirical evidence of an inverse relation between volume and volatility is rare in the literature, and it contrasts sharply with the widely held perception that volume and volatility are positively related. Critics of futures markets embrace this common perception, arguing that volatility is caused largely by excesses in speculative trading and calling for regulatory intervention to curb trading in times of market stress. However, proponents of futures markets argue that market volatility is caused by information arrival. This group objects to any regulatory action that would hamper the free flow of information and trading activity.

The results of our study suggest that market depth and providers of liquidity can have an important bearing on the level of volatility. Our results call into question the merit of regulatory restrictions on trading activity that are prescribed to dampen market volatility, such as circuit breakers. On the basis of our analysis, it is not clear that trading curbs such as circuit breakers will have the desired effect. Instead, they may actually exacerbate, rather than attenuate, market volatility.

This article proceeds as follows. The next section describes the institutional setting behind quarterly redesignation of the lead S&P 500 futures contract and shows how this event affects relative trading volumes in the nearby and next out contracts. This discussion is followed by a review of the literature on the volume–volatility relation. Next, the data are described, along with our model and hypothesis tests. The results are then presented. A final section concludes the article.

REDESIGNATION OF THE LEAD CONTRACT

The *nearby* is the contract with the most imminent expiration, and the *next out* is the second-to-expire contract. Until shortly before it expires, the nearby is the most actively traded contract maturity. Because of this distinction, the nearby is designated by the exchange as the lead contract. As such, it trades in a location in the pit dedicated to the lead contract. However, as each quarterly expiration approaches, the concentration of trading volume begins to shift from the nearby to the next out. At some point after the market's daily close, the CME formally announces that on the following business day the next out will be designated as the new lead contract. The next out contract then replaces the nearby in the lead contract location in the pit.

Before the early 1990s, the CME selected a different date for this event every quarter, based on when market participants began to roll over their positions. Recently, the CME revised their procedure to ensure that the switch occurs at the same time each quarter, by designating the Thursday before the second Friday of the S&P 500 contract expiration month as the date for this switch in pit positions. Other contracts follow their own procedures for determining the timing of this redesignation. For example, the same date is chosen each contract period for the CME currency contracts, whereas for Eurodollar contracts the exchange still selects and announces a different date every contract period.

After the CME reassignment of pit positions, volume migrates suddenly and dramatically from the nearby to the next out (Ekman, 1991). This phenomenon is documented in Panel A of Table I and in Figure 1, which show average daily trading volume in the nearby and next out contracts on the 5 days leading up to and the 5 days following contract redesignation. The daily data are averaged across the 64 quarterly events from 1983 to 1998. The 5 days leading up to redesignation (Days −5, −4, −3, −2, and −1) include the day the CME announces redesignation after the market closes (Day −1). Days +1, +2, +3, +4, and +5 are the 5 days immediately after this announcement.

The average total volume across the two contracts (the vertical sum in Figure 1) reflects the average, aggregate trading activity in these two contracts for all purposes (i.e., speculation, hedging, and arbitrage), including the desire to roll over positions. This combined volume experiences a roughly 30% increase leading up to redesignation, from Day −5 to Day +1, presumably reflecting the additional activity involved in rolling over positions near expiration. Although day-to-day changes in average total volume remain fairly stable around this trend, the shift from the nearby to the next out is concentrated on the day after redesignation (i.e., on Day +1). Importantly, the day-to-day changes in average total volume across the two contracts are small relative to the roughly 700% increase in average volume for the next out (or the proportionate decline for the nearby) before and after this event. To the extent that the relative change in trading volumes is due to this quarterly institutional feature of the market microstructure, it may be considered exogenous with respect to new information or underlying volatility conditions at the time of the event.

Consider average daily volatility on the 5 days before (pre) and 5 days after (post) redesignation of the lead contract, provided in Panel B of Table I. Note that, for the next out (nearby) contract, average volatility tends to increase (decline) along with volume after redesignation.

TABLE I

Descriptive Statistics: Volume and Volatility on the 10 Days Surrounding Redesignation of the Lead Contract

	Full Period: 1983–1998				Subperiod I: 1983–1987				Subperiod II: 1988–1993				Subperiod III: 1994–1998			
	Nearby		Next Out		Nearby		Next Out		Nearby		Next Out		Nearby		Next Out	
Day	*M*	*STD*	*M*	*STD*	*M*	*STD*	*M*	*STD*	*M*	*STD*	*M*	*STD*	*M*	*STD*	*M*	*STD*
Panel A: Volume																
−5	63,858	32,346	9,663	6,315	58,152	25,805	8,855	4,058	43,890	8,784	6,208	2,055	85,849	37,176	13,326	8,200
−4	67,078	30,936	10,765	5,522	56,620	21,274	8,806	2,837	48,315	8,226	8,021	3,143	91,776	34,061	14,716	6,503
−3	60,060	24,156	11,758	5,638	54,865	19,891	9,422	2,876	43,669	7,150	8,956	3,550	78,516	24,923	16,058	6,219
−2	66,529	28,715	15,217	7,207	57,379	24,554	11,766	4,222	50,917	8,020	11,460	3,560	87,434	31,355	21,236	7,534
−1	71,545	32,393	21,189	12,115	57,553	24,599	13,910	4,799	54,156	10,216	15,450	4,881	97,838	33,921	31,972	12,967
1	32,639	21,298	66,541	36,948	20,212	9,459	50,213	19,987	23,056	4,036	45,661	7,848	50,863	24,501	97,737	41,707
2	22,079	13,633	70,879	35,098	14,865	6,699	58,088	22,645	15,894	3,078	47,732	7,839	33,204	16,083	1,01,259	36,498
3	20,011	15,653	67,356	35,444	11,410	4,394	59,416	19,993	13,216	2,746	44,856	7,097	32,766	19,402	93,331	43,199
4	20,563	14,053	74,400	33,450	10,032	4,089	65,492	17,844	13,919	3,525	50,723	10,161	32,958	14,584	1,00,684	36,085
5	20,460	12,918	75,731	33,509	10,773	3,788	68,443	18,192	13,593	2,855	51,764	10,482	31,313	13,320	1,00,347	35,996
pre	65,814	29,923	13,718	8,769	56,914	22,859	10,552	4,259	48,189	9,310	10,019	4,743	88,283	32,639	19,462	10,899
post	23,245	16,514	70,830	34,928	13,845	7,274	59,409	20,502	15,936	4,901	48,147	9,043	36,221	19,201	98,671	38,277
Panel B: Volatility[a]																
−5	6.02	6.97	6.08	7.67	5.48	4.31	5.51	4.08	6.36	7.79	6.76	9.39	6.14	8.09	5.95	8.39
−4	9.09	8.93	7.05	6.77	7.19	6.70	6.78	6.23	6.33	5.79	6.17	5.25	13.00	11.30	8.03	8.34
−3	5.96	9.75	5.63	8.78	6.24	4.78	6.37	5.32	4.90	3.82	4.79	3.81	6.67	15.10	5.77	13.20
−2	6.24	6.80	5.97	6.34	7.35	7.24	7.54	6.99	5.95	6.08	5.90	5.99	5.60	7.20	4.80	6.12
−1	5.62	5.15	5.73	5.67	6.44	5.11	7.86	7.15	5.79	6.06	5.61	5.92	4.82	4.35	4.16	3.34
1	6.71	9.43	6.55	8.95	6.38	8.35	8.10	8.97	6.61	12.30	6.60	12.20	7.07	7.57	5.28	4.84
2	8.78	12.50	9.34	15.70	8.09	15.10	8.31	11.30	6.36	5.97	6.56	6.05	11.40	14.30	12.60	22.90
3	5.22	5.31	6.35	8.28	5.79	4.97	7.17	6.34	4.26	4.58	4.04	3.49	5.62	6.19	7.73	11.80
4	5.53	5.15	5.98	5.69	4.97	3.38	6.03	3.89	6.22	6.52	6.09	6.43	5.27	4.86	5.84	6.15
5	5.55	5.60	6.00	5.36	7.01	4.94	9.00	5.95	5.21	5.61	5.38	5.41	5.11	6.00	5.04	4.64
pre	6.58	7.75	6.09	7.10	6.54	5.66	6.81	5.99	5.87	5.95	5.85	6.26	7.25	10.20	5.74	8.49
post	6.39	8.27	6.87	9.68	6.47	8.71	7.70	7.89	5.74	7.41	5.73	7.24	6.90	8.69	7.30	12.30

Note. This table provides the mean and standard deviation for volume and volatility on each of the 5 days before and 5 days after redesignation. The rows labeled *pre* and *post* give mean values over the 5 days before (Days −5 to −1) and 5 days after (Days 1–5) redesignation.

[a]All values in Panel B are multiplied by 10^5 for ease of exposition.

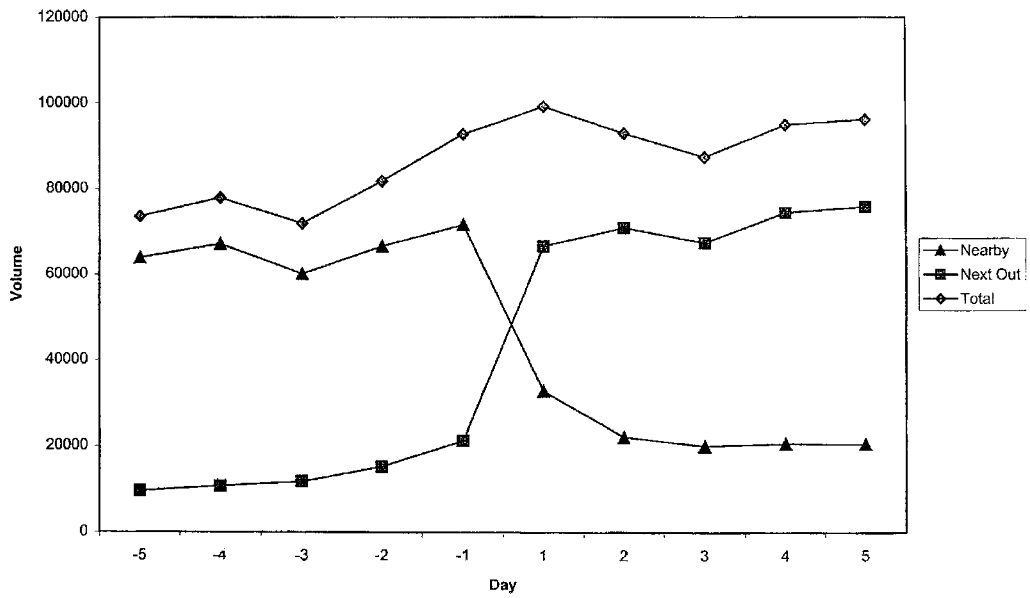

FIGURE 1

Average daily volume on the 10 days surrounding redesignation of the lead S&P 500 futures contract across all 64 quarterly events from 1983 to 1998.

However, average volatility does not change by nearly the same proportion as volume. Furthermore, average volatility does not change in the same direction as volume for all subsamples. This study analyzes the extent of the association between daily movements in volume and volatility for the nearby and next out contracts, on the 5 days before and after redesignation. After accounting for this association between volume and volatility, we formally test whether the level of volatility still tends to move in the same direction as volume after redesignation, for both the nearby and next out contracts.

LITERATURE REVIEW

The large volume of literature on the relation between market liquidity and volatility reflects the intense interest of various constituents. For example, market participants need to know how volatility interacts with other facets of market behavior to identify situations to avoid or opportunities to exploit. Exchange members and regulators are concerned if volatility is excessive in some sense and, if so, what steps can be taken to mitigate the problem. This particular issue took center stage after the crash of October 1987, when critics claimed that increased activity in

S&P 500 futures markets resulted in greater volatility in both futures and spot markets. The implementation of circuit breakers was one outcome of this debate.

Theoretical Background

The theoretical foundation behind the volume–volatility relation rests on how information arrives and is processed in the marketplace. The mixture of distributions hypothesis relies on information arrival as a mixing event that has a positive influence on both volume and volatility.[2] According to this theory, unexpected information causes market participants to revise expectations. Volume and volatility increase together as market participants trade on the new information.

Asymmetric information models of price discovery emphasize the interaction of informed traders, uninformed traders, and market makers following the arrival of information.[3] Models of heterogeneous behavior consider how different participants process information differently. Some authors developed theories based on the role of dispersion of beliefs across traders (Harris & Raviv, 1993; Shalen, 1993). For example, Shalen built a model in which greater dispersion of beliefs creates excess price variability and excess volume, relative to their equilibrium levels. In Shalen's model, volatility results from uninformed traders' dispersion of beliefs that are incorrectly derived from the noisy liquidity demand of hedgers.[4] One implication is that uninformed traders as a group are characterized by greater dispersion of beliefs than informed traders. As a result, trading activity by uninformed investors induces greater price volatility than trading by other market participants.

[2]See Clark (1973), Epps and Epps (1976), Grammatikos and Saunders (1986), Harris (1987), and Tauchen and Pitts (1983).

[3]Models that rely on different types of traders to develop the relation between trading activity and price formation include Admati and Pfleiderer (1988), Brown and Zhang (1997), Easley and O'Hara (1987), Foster and Viswanathan (1990), Glosten and Milgrom (1985), Holden and Subrahmanyam (1992), Kyle (1985), Shalen (1993), Spiegel and Subrahmanyam (1992), and Subrahmanyam (1991).

[4]Bessembinder et al. (1996) and Harris and Raviv (1993) labeled this phenomenon *differences of opinion,* whereas Bamber, Barron, and Stober (1999) pointed to *differential interpretation of information* as a cause of both volume and volatility. Along the same lines, Verrecchia (1981) and Holthausen and Verrecchia (1990) emphasized the degree of consensus regarding new information. Other authors focused on differences in the quality or precision of the information itself as a force behind both trading activity and price volatility (Blume, Easley, & O'Hara, 1994; He & Hwang, 1995; Kim & Verrechia, 1991a, 1991b). Whatever the focus of these models, the implication is the same: a greater dispersion of beliefs may result in greater trading activity and price volatility.

Other authors considered the potential differential behavior of different groups of traders in the market.[5] For example, Daigler and Wiley (1999) explicitly analyzed the volume–volatility relation by trader type. They found empirical evidence indicating that the positive volume–volatility relation is driven by the (uninformed) general public. Daigler and Wiley also found that the activity of informed traders such as clearing members and floor traders is often inversely related to volatility. This result suggests that providers of liquidity have an attenuating influence on the volume–volatility relation.

Economic Rationale for the Inverse Relation Between Volume and Volatility

One rationale for a negative impact of noninformation-based changes in volume on volatility focuses on the composition of trading activity in the marketplace. Consider the role of liquidity providers (i.e., dealers and market makers) and the depth of the market. Prices adjust when the demand for liquidity exceeds the capacity of market makers to absorb order flow at current prices. All else being equal, a marketplace with a larger population of liquidity providers (or a larger capacity to absorb demands for liquidity) will be less volatile than one with a smaller population, and vice versa.

Newly initiated customer positions, whether originating because of hedging or speculative motives, reflect a demand for liquidity that is largely motivated by the arrival of new information. This trading behavior contrasts with the activity of market makers, which occurs independently of information arrival. We suggest that an increase in such noninformation-based trading mitigates the imbalances between liquidity suppliers and liquidity demanders by enhancing the market's capacity to absorb the information-induced trading. We hypothesize that the larger population of liquidity providers concentrated in the lead contract reduces volatility, as the enhanced market depth absorbs more of the imbalances between buyers and sellers that result from information-based trading. Coincidentally, the smaller population of liquidity providers associated with the nonlead contract fosters a diminished capacity to absorb these imbalances.

[5]See Bessembinder and Seguin (1992), Daigler and Wiley (1999), Easley and O'Hara (1987), Glosten and Milgrom (1985), and Kyle (1985).

Previous Empirical Evidence on the Volume–Volatility Relation

The empirical literature indicates that volume and volatility are contemporaneously related.[6] Under normal circumstances, we would expect volume and volatility to be jointly determined throughout the course of a typical trading day. Thus, volume and volatility could be related in the context of a structural simultaneous equations model. The contemporaneous correlation between volume and volatility discussed previously is consistent with a simultaneous relation, but this correlation does not speak to the question of whether volume and volatility influence each other within the specified time frame. Very few earlier studies directly address this simultaneity.[7]

Evidence of a positive contemporaneous association between volume and volatility is predominant in this literature. The evidence includes a plethora of time series studies.[8] An alternative approach is the work of French and Roll (1986), who compared volatility from trading and nontrading periods and found that volatility is greater when the exchange is open than when it is closed. One possible conclusion is that volatility is to some extent caused by trading itself. Another alternative approach was presented by Lamoureux and Poon (1987), who examined volatility and trading volume patterns of individual stocks surrounding the ex date of stock splits and reverse stock splits. Such an ex date should have little economic significance. However, for stock splits they found an increase in the number of transactions and volatility of stocks, whereas for reverse splits they found a reduction in trading and volatility.

Finally, there is a body of literature that documents an inverse relation. As discussed previously, an inverse relation may reflect a change in the composition of traders and market depth, associated with an increase in noninformation-based trading. For example, an increase in the population of liquidity providers relative to overall trading activity increases

[6]For example, see Admati and Pfleiderer (1988); Bessembinder and Seguin (1992); Bessembinder et al. (1996); Clark (1973); Cornell (1981); Daigler and Wiley (1999); Ederington and Lee (1993, 1995); Epps and Epps (1976); Foster (1995); Foster and Viswanathan (1993, 1995); Garcia et al. (1986); Grammatikos and Saunders (1986); Heimstra and Jones (1994); Jones, Kaul, and Lipson (1994a, 1994b); Karpoff (1987); Lamoureaux and Lastrapes (1990, 1994); Lauterbach and Monroe (1989); Lee, Ready, and Seguin (1994); Merrick (1987); Mitchell and Mulherin (1994); Morgan (1976); Rutledge (1979); Upton and Shannon (1979); Tauchen and Pitts (1983); and Taylor (1985).

[7]See Chan and Chung (1993, 1995), Koch (1993), and Lamoureaux and Lastrapes (1994).

[8]Time series studies that support this result include Bessembinder and Seguin (1992), Bessembinder et al. (1996), Clark (1973), Cornell (1981), Epps and Epps (1976), Foster (1995), Garcia et al. (1986), Grammatikos and Saunders (1986), Jain and Joh (1988), Karpoff (1987), Kawaller et al. (1990), Kawaller et al. (1994), Rutledge (1979), Upton and Shannon (1979), and Wood et al. (1985).

the depth of the market and may attenuate price volatility. Daigler and Wiley (1999) found that, although trading by the public (uninformed investors) increases volatility, trading by clearing members and floor traders (informed investors) often decreases volatility. Limited anecdotal evidence points to such a negative relation between volume and volatility. Tauchen and Pitts (1983) examined the 90-day Treasury bill futures market after its inception and found declining volatility over time as the number of traders and trading volume increase. Anecdotal evidence also suggests that volatility and volume in S&P 500 futures may vary inversely. For several years immediately after the October 1987 crash, S&P 500 futures volatility was generally greater whereas trading volume was lower relative to the levels of the precrash period. This increase in volatility might have resulted from a change in the composition of traders supplying S&P 500 futures liquidity after the crash.[9]

Our study measures the nature and extent of a possible systematic change in volatility behavior surrounding quarterly redesignation of the lead S&P 500 futures contract. We argue that any systematic response in volatility behavior surrounding this quarterly event is likely attributable to the one common feature across all events: the exogenous change in relative trading volumes associated with the switch in pit positions. This analysis, therefore, sidesteps the issue of simultaneity and facilitates a novel investigation of the influence of noninformation-based changes in volume on market volatility.

DATA

We obtained daily data on volume and prices for the nearby and next out S&P 500 futures contracts from the Futures Industry Institute for the period 1983–1998. Futures price data include the daily high, low, open, and close. We use these data to generate daily measures of intraday futures price volatility. The sample period of interest includes a 10-day window, the 5 days leading up to and the 5 days following redesignation of the lead futures contract, for each of the 64 quarterly events from 1983 to 1998. Our goal is to identify any systematic changes in the level of volatility, or in the association between volume and volatility, on the days surrounding this quarterly volume-altering event.

[9]In another market arena, Stoll and Whaley (1990) examined individual New York Stock Exchange stocks and found volatility was lower when volume was greater. These results are consistent with the argument that higher trading volume improves liquidity and reduces bid–ask spreads, so that smaller price swings will reestablish equilibrium (see also Copeland & Galai, 1983; Martell & Trevino, 1990).

First, using data on the daily high, low, open, and closing prices in each contract, we generate a daily measure of intraday price volatility for both the nearby and next out contracts. We can choose from among several alternative measures, each of which uses different information from the available daily price data (Garman & Klass, 1980; Kunitomo, 1992; Parkinson, 1980). We use four alternative measures, with robust results. For brevity, we provide only the results for the following measure proposed by Garman and Klass:

$$\sigma_t^2 = 0.511(u_t - d_t)^2 - 0.019[c_t(u_t + d_t) - 2u_t d_t] - 0.383c_t^2$$

where u_t = log(High price/Opening price on Day t), d_t = log(Low price/Opening price on Day t), and c_t = log(Closing price/Opening price on Day t). Results for the alternative measures are available on request.[10]

We measure liquidity in both the nearby and next out contracts by total daily trading volume. Bessembinder and Seguin (1992) suggested that linking volatility to total volume does not extract all relevant information about the relation. They used an autoregressive (AR) model to partition volume into expected and unexpected components, and they found the two components have separate effects on volatility.

To investigate whether expected and unexpected volume separately impact volatility, we generate daily measures of expected and unexpected volume over the 5 days leading up to and the 5 days following each quarterly event. We first estimate an AR model that generates measures of expected daily percentage changes in volume based on past percentage changes in volume for the nearby and next out contracts. For each quarterly event, we estimate this model over the time series of daily percentage changes in volume from the previous expiration date until 5 days before redesignation. Following Bessembinder and Seguin (1992) and Daigler and Wiley (1999), we do not attempt to find the ideal AR model for each quarterly time series. Instead, we choose an arbitrarily long lag length of 5 business days, and we estimate this AR(5) model for the nearby and the next out contracts separately over each quarterly contract period. We then use the estimated model for each quarterly sample period to

[10]The alternative volatility measures we have analyzed include the following:

$$\sigma_{\mathrm{I}t}^2 = \ln(\mathrm{High}_t/\mathrm{Low}_t)$$
$$\sigma_{\mathrm{II}t}^2 = [\ln(\mathrm{High}_t/\mathrm{Low}_t)]^2/(4 \log_e 2)$$
$$\sigma_{\mathrm{III}t}^2 = 0.12[(\ln(\mathrm{Open}_t/\mathrm{Close}_{t-1})]^2/f) + (1 - 0.12)[s_t^2/(1 - f)]$$

where f is the fraction of day from yesterday's close to today's open [(17 hr, 5 min)/(24 hr) = 0.7118] for the S&P 500 futures market. Parkinson (1980) and Kunitomo (1992) proposed the first volatility measure listed, $\sigma_{\mathrm{I}t}^2$. Garman and Klass (1980) recommended the remaining measures.

generate fitted values of the percentage change in daily volume for the 5 days before and the (up to) 5 days following redesignation. (In the 1980s, this quarterly event occasionally took place with fewer than 5 days remaining before expiration of the nearby. Hence, for some quarterly events there are fewer than 5 days of observations on the nearby contract following the event.) These fitted values represent anticipated or expected percentage changes in the level of daily volume for the (up to) 10 days surrounding each quarterly redesignation. We then multiply the actual volume on Day $t - 1$ by (1 + fitted value) to get the expected level of volume on Day t (EV_{ijt}). Finally, our measure of unexpected volume is simply the actual volume minus the expected volume ($UV_{ijt} = V_{ijt} - EV_{ijt}$).

Given these measures of expected, unexpected, and total daily volume, we apply a general linear model (GLM) analysis in three ways. First, we relate actual total volume to volatility movements on the 10 days surrounding this quarterly event. Second, we relate both expected and unexpected volume to volatility. Third, we note that other factors could also influence the relations investigated here. For example, Bessembinder and Seguin (1992) and Daigler and Wiley (1999) found that lagged volatility plays a role. Incorporating lagged volatility in the GLM allows an assessment of whether the persistence in volatility affects any systematic relations between volume and volatility. We investigate this possibility in our third application of the analysis.

GLM ANALYSIS

Model and Hypotheses

We can use GLM analysis to examine the null hypothesis that volatility behavior is unrelated to changes in volume on the 5 days before and 5 days after this quarterly event. This approach uses a pooled dummy regression for both the nearby and next out contracts. We partition the 10 daily observations surrounding all 64 quarterly events in two different ways, according to whether each observation involves (a) the nearby or the next out contract and (b) the high-volume (lead) or low-volume (nonlead) pit position for each contract. The model takes the following form:

$$\sigma^2_{ijt} = \alpha_1 + \alpha_2 P_{ij} + \alpha_3 C_{ij} + \alpha_4 P_{ij} C_{ij} + \beta_1 V_{ijt} + \beta_2 P_{ij} V_{ijt} + \beta_3 C_{ij} V_{ijt} + \beta_4 P_{ij} C_{ij} V_{ijt} + \varepsilon_{ijt} \quad (1)$$

where σ^2_{ijt} is the volatility measure for the (i,j,t)th observation, i indexes the event (quarterly sample period, 1–64), j indexes the contract (nearby or next out), and t is the day relative to the event (−5, −4, −3, −2, −1,

+1, +2, +3, +4, +5).[11] P_{ij} is 1 if the (i,j,t)th observation is for the lead contract (high-volume pit position) and 0 if the (i,j,t)th observation is for the nonlead contract (low-volume pit position); C_{ij} is 1 if the (i,j,t)th observation is in the nearby contract sample, 0 if the (i,j,t)th observation is in the next out contract sample; V_{ijt} is the daily trading volume in the jth contract (nearby or next out) for Event i and Day t; ε_{ijt} is the error term for the (i,j,t)th observation.

This GLM incorporates two dummy variables to identify first the pit position as the lead or nonlead contract (P_{ij}) and second the nearby or next out contract (C_{ij}). The model also includes the continuous variable, V_{ijt}. By incorporating both V_{ijt} and P_{ij} in Equation 1, we investigate the influence of each variable on volatility, holding the other constant. The capabilities of this model can be illuminated if we consider the effective model for the nearby and next out contract subsamples separately:

$$\text{nearby } (C_{ij} = 1)\text{: } \sigma^2_{ijt} = (\alpha_1 + \alpha_3) + (\alpha_2 + \alpha_4)P_{ij} + (\beta_1 + \beta_3)V_{ijt} + (\beta_2 + \beta_4)P_{ij}V_{ijt} + \varepsilon_{ijt}; \qquad (1a)$$

$$\text{next out } (C_{ij} = 0)\text{: } \sigma^2_{ijt} = \alpha_1 + \alpha_2 P_{ij} + \beta_1 V_{ijt} + \beta_2 P_{ij} V_{ijt} + \varepsilon_{ijt} \qquad (1b)$$

Our model allows us to address three critical issues. First, for both the next out and nearby contracts, we investigate possible systematic changes in the level of volatility when the contract changes pit positions through the coefficient of P_{ij} (α_2 or $\alpha_2 + \alpha_4$). This coefficient measures the influence of the pit position (designated as lead or nonlead contract) on volatility in each futures contract. That is, the coefficient, α_2 in Equation 1b (or $\alpha_2 + \alpha_4$ in Equation 1a) measures the average change in the level of volatility when the next out [or nearby] contract switches trading between low-volume and high-volume pit positions.

The statistical issue we address here is whether the change in pit position (with its known effect on the level of volume) is systematically associated with a significant change in the level of volatility for either or both contracts across all events. The relevant null hypotheses for this first issue are the following:

H_1. $\alpha_2 = 0$: no change in the level of volatility for the next out contract ($C_{ij} = 0$) between low-volume and high-volume pit positions.

H_2. $\alpha_2 + \alpha_4 = 0$: no change in the level of volatility for the nearby contract ($C_{ij} = 1$) between low-volume and high-volume pit positions.

[11]Note that redesignation is announced after the market's close on Day −1. Day + 1 is then the next (1st) day after redesignation.

Under H_1 and H_2, pit position (P_{ij}) does not influence the level of volatility for the next out and nearby contracts, respectively. However, a positive coefficient of P_{ij} ($\alpha_2 > 0$ or $\alpha_2 + \alpha_4 > 0$) would imply that return volatility is greater when the contract is traded in the higher volume pit position (as the lead contract). Such a result would suggest that higher volumes associated with the lead contract exacerbate volatility. In contrast, a negative coefficient would imply that volatility is lower when the contract is traded in the higher volume pit position, supporting the hypothesis that higher volumes of the lead contract attenuate volatility.

In sum, these two hypotheses shed light on whether the higher volume pit position systematically experiences a higher or lower level of volatility after we account for changes in volatility across contracts and events that are due to changes in volume (i.e., after we control for V_{ijt}).

The second issue involves the nature and extent of the association between trading volume (V_{ijt}) and return volatility (σ^2_{ijt}) in each pit position. We address this issue by examining the magnitude and significance of the volume coefficient across various subsamples (β_i; $i = 1, 2, 3, 4$). The coefficient of V_{ijt} in Equations 1a and 1b measures this association for each contract when the contract is traded in the low-volume pit position (as the nonlead contract; $P_{ij} = 0$). The coefficient of $P_{ij}V_{ijt}$ then reveals how this association changes when each contract is traded in the high-volume pit position (as the lead contract; $P_{ij} = 1$). Specifically, we are interested in the following four hypotheses:

H_3. $\beta_1 = 0$: no association between V_{ijt} and σ^2_{ijt} for the next out contract ($C_{ij} = 0$) while it is traded as the nonlead contract ($P_{ij} = 0$).

H_4. $\beta_1 + \beta_3 = 0$: no association between V_{ijt} and σ^2_{ijt} for the nearby contract ($C_{ij} = 1$) while it is traded as the nonlead contract ($P_{ij} = 0$).

H_5. $\beta_1 + \beta_2 = 0$: no association between V_{ijt} and σ^2_{ijt} for the next out contract ($C_{ij} = 0$) while it is traded as the lead contract ($P_{ij} = 1$).

H_6. $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 0$: no association between V_{ijt} and σ^2_{ijt} for the nearby contract ($C_{ij} = 1$) while it is traded as the lead contract ($P_{ij} = 1$).

The coefficient sums tested in H_3 and H_4 (β_1 and $\beta_1 + \beta_3$) reflect the association between volume and volatility for the next out and nearby contracts, respectively, while each contract is traded in the low-volume pit position as the nonlead contract ($P_{ij} = 0$). The coefficient sums tested in H_5 and H_6 ($\beta_1 + \beta_2$ and $\beta_1 + \beta_2 + \beta_3 + \beta_4$) reveal the same association when each contract is traded as the high-volume lead contract ($P_{ij} = 1$).

The third issue involves whether the extent of this association between volume and volatility changes substantively when each contract changes pit positions. This issue is revealed by the coefficient of $P_{ij}V_{ijt}$ in Equations 1a and 1b and can be investigated formally with the following hypotheses:

H_7. $\beta_2 = 0$: no change in association between V_{ijt} and σ^2_{ijt} for the next out contract ($C_{ij} = 0$) when it changes from the nonlead to lead contract ($P_{ij} = 0$ to 1).

H_8. $\beta_2 + \beta_4 = 0$: no change in association between V_{ijt} and σ^2_{ijt} for the nearby contract ($C_{ij} = 1$) when it changes from the nonlead to lead contract ($P_{ij} = 0$ to 1).

A significant negative value for β_2 (or $\beta_2 + \beta_4$) would suggest the association between volume and volatility is attenuated for the next out (or nearby) contract when trading occurs in the higher volume pit position. Such a result would be consistent with the liquidity hypothesis, suggesting that greater liquidity associated with the lead contract designation results in a weaker association between volume and volatility.[12]

Panel A of Table II summarizes the capabilities of the GLM in Equations 1, 1a, and 1b in terms of these three issues and the related hypotheses, H_1 to H_8. We can expand this model to incorporate both expected volume (EV_{ijt}) and unexpected volume (UV_{ijt}) and thereby investigate possible distinct relations involving these two components of trading activity. Panel B of Table II gives the analogous hypotheses for this expanded model. Finally, we can expand the model further by adding lagged volatility to assess the role of persistence in volatility in these relations. Results of these three approaches appear later.

In all three approaches, we estimate the model over the entire sample period (1983–1998) and three subperiods: 1983–1987, 1988–1993, and 1994–1998. By partitioning the data in this fashion, we can see the stability of any systematic relations between volume and volatility during three distinct periods that were characterized by divergent behavior in

[12]As an illustration, suppose that volume and volatility in the next out contract both increase by 10% on successive days before redesignation at one quarterly event. Then, on successive days after redesignation, suppose the next out contract experiences a larger volume increase of 20% along with a smaller increase in volatility of only 5%. Note that volume and volatility increase together on both pairs of successive days, implying a positive contemporaneous correlation between volume and volatility both before and after redesignation. However, when we consider the magnitudes of the changes in volume and volatility before and after redesignation, it is apparent in this illustration that a larger increase in volume is associated with a smaller change in volatility. Such behavior would suggest that greater liquidity associated with the lead contract designation attenuates the correlation between volume and volatility, consistent with the liquidity hypothesis.

TABLE II
Regression Model and Hypotheses

Panel A: GLM Relating Total Volume and Volatility

$$\sigma^2_{ijt} = \alpha_1 + \alpha_2 P_{ij} + \alpha_3 C_{ij} + \alpha_4 P_{ij} C_{ij} + \beta_1 V_{ijt} + \beta_2 P^*_{ij} V_{ijt} + \beta_3 C^*_{ij} V_{ijt} + \beta_4 P^*_{ij} C^*_{ij} V_{ijt} + \varepsilon_{ijt} \quad (1)$$

nearby ($C_i = 1$): $$\sigma^2_{ijt} = (\alpha_1 + \alpha_3) + (\alpha_2 + \alpha_4) P_{ij} + (\beta_1 + \beta_3) V_{ijt} + (\beta_2 + \beta_4) P^*_{ij} V_{ijt} + \varepsilon_{ijt} \quad (1a)$$

next out ($C_i = 0$): $$\sigma^2_{ijt} = \alpha_1 + \alpha_2 P_{ij} + \beta_1 V_{ijt} + \beta_2 P^*_{ij} V_{ijt} + \varepsilon_{ijt} \quad (1b)$$

where σ^2_{ijt} is the daily volatility in S&P 500 futures returns for the (i,j,t)th observation, i indexes the event (quarterly sample period, 1–64), j indexes the contract (nearby or next out), and t indexes the day relative to the event (−5, −4, −3, −2, −1, +1, +2, +3, +4, +5). V_{ijt} is the total daily volume in the jth contract (nearby or next out) for Quarterly event i and Day t; P_{ij} is 1 if the (i,j,t)th observation is for the lead contract (high-volume pit position) and 0 if the (i,j,t)th observation is for the non-lead contract (low-volume pit position). C_{ij} is 1 if the (i,j,t)th observation is in the nearby contract sample and 0 if the (i,j,t)th observation is in the next out contract sample.

Hypothesis	*Description*
	First Issue: Impact of Contract Redesignation on the Level of Volatility
H_1: $\alpha_2 = 0$	No change in the level of volatility for next out ($C_{ij} = 0$) between low-volume and high-volume pit positions.
H_2: $\alpha_2 + \alpha_4 = 0$	No change in the level of volatility for nearby ($C_{ij} = 1$) between low-volume and high-volume pit positions.
	Second Issue: Existence of Association Between Volume and Volatility
H_3: $\beta_1 = 0$	No association between V_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) while nonlead contract ($P_{ij} = 0$).
H_4: $\beta_1 + \beta_3 = 0$	No association between V_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 1$) while nonlead contract ($P_{ij} = 0$).
H_5: $\beta_1 + \beta_2 = 0$	No association between V_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) while lead contract ($P_{ij} = 1$).
H_6: $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 0$	No association between V_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 1$) while lead contract ($P_{ij} = 1$).
	Third Issue: Impact of Contract Redesignation on Association Between Volume and Volatility
H_7: $\beta_2 = 0$	No change in association between V_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) from ($P_{ij} = 0$ to $P_{ij} = 1$).
H_8: $\beta_2 + \beta_4 = 0$	No change in association between V_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 0$) from ($P_{ij} = 0$ to $P_{ij} = 1$).

Panel B: GLM Relating Expected and Unexpected Volume to Volatility[a]

$$\sigma^2_{ijt} = \alpha_1 + \alpha_2 P_{ij} + \alpha_3 C_{ij} + \alpha_4 P_{ij} C_{ij} + \beta_1 EV_{ijt} + \beta_2 P_{ij} EV_{ijt} + \beta_3 C_{ij} EV_{ijt} + \beta_4 P_{ij} C_{ij} EV_{ijt} + \gamma_1 UV_{ijt} + \gamma_2 P_{ij} UV_{ijt} + \gamma_3 C_{ij} UV_{ijt} + \gamma_4 P_{ij} C_{ij} UV_{ijt} + \varepsilon_{ijt} \quad (2)$$

nearby ($C_{ij} = 1$): $$\sigma^2_{ijt} = (\alpha_1 + \alpha_3) + (\alpha_2 + \alpha_4) P_{ij} + (\beta_1 + \beta_3) EV_{ijt} + (\beta_2 + \beta_4) P_{ij} EV_{ijt} + (\gamma_1 + \gamma_3) UV_{ijt} + (\gamma_2 + \gamma_4) P_{ij} UV_{ijt} + \varepsilon_{ijt} \quad (2a)$$

next out ($C_{ij} = 0$): $$\sigma^2_{ijt} = \alpha_1 + \alpha_2 P_{ij} + \beta_1 EV_{ijt} + \beta_2 P_{ij} EV_{ijt} + \gamma_1 UV_{ijt} + \gamma_2 P_{ij} UV_{ijt} + \varepsilon_{ijt} \quad (2b)$$

(Continued)

TABLE II
(Continued)

Hypothesis	*Description*
Second Issue: Existence of Association Between Expected Volume and Volatility	
H_3: $\beta_1 = 0$	No association between EV_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) while nonlead contract ($P_{ij} = 0$).
H_4: $\beta_1 + \beta_3 = 0$	No association between EV_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 1$) while nonlead contract ($P_{ij} = 0$).
H_5: $\beta_1 + \beta_2 = 0$	No association between EV_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) while lead contract ($P_{ij} = 1$).
H_6: $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 0$	No association between EV_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 0$) while lead contract ($P_{ij} = 1$).
Third Issue: Impact of Contract Redesignation on Association Between Expected Volume and Volatility	
H_7: $\beta_2 = 0$	No change in association between EV_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) from (P_{ij} = 0–1).
H_8: $\beta_2 + \beta_4 = 0$	No change in association between EV_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 1$) from (P_{ij} = 0–1).
Second Issue: Existence of Association Between Unexpected Volume and Volatility	
H_9: $\gamma_1 = 0$	No association between UV_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) while nonlead contract ($P_{ij} = 0$).
H_{10}: $\gamma_1 + \gamma_3 = 0$	No association between UV_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 1$) while nonlead contract ($P_{ij} = 0$).
H_{11}: $\gamma_1 + \gamma_2 = 0$	No association between UV_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) while lead contract ($P_{ij} = 1$).
H_{12}: $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 = 0$	No association between UV_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 0$) while lead contract ($P_{ij} = 1$).
Third Issue: Impact of Contract Redesignation on Association Between Unexpected Volume and Volatility	
H_{13}: $\gamma_2 = 0$	No change in association between UV_{ijt} and σ^2_{ijt} for next out ($C_{ij} = 0$) from (P_{ij} = 0–1).
H_{14}: $\gamma_2 + \gamma_4 = 0$	No change in association between UV_{ijt} and σ^2_{ijt} for nearby ($C_{ij} = 1$) from (P_{ij} = 0–1).

Note. This table summarizes the dummy regression models estimated and the hypotheses tested in this article. Panel A presents the model used to relate daily movements in total volume to the level of volatility and to the extent of association between volume and volatility surrounding redesignation of the lead contract. Panel B provides an expanded model to examine the influence of both expected and unexpected movements in daily volume on the level of volatility and the extent of association between volume and volatility surrounding redesignation.

[a]The investigation of the influence of both expected and unexpected movements in daily volume (EV_{ijt} and UV_{ijt}) on volatility behavior requires an expanded model and additional hypotheses. The expanded model and the associated hypotheses are provided. The former hypotheses regarding the first issue (H_1 and H_2) remain the same in this expanded model. H_3 to H_8 are also analogous to the same hypotheses as before, but now they refer to the behavior of expected volume, EV_{ijt}. In addition, we now add six new hypotheses, also analogous to the former H_3 to H_8, which apply to the behavior of unexpected volume, UV_{ijt}.

S&P 500 futures activity. The first period began with low volume and experienced rapid growth before the 1987 crash. The second period encountered a decline in activity of about 50% after the crash before volume gradually returned to precrash levels. The third period showed sustained growth in equity and futures index trading.[13]

GLM Results With Total Volume

Table III presents the results with the total volume (V_{ijt}) in Equation 1. By examining the three different sets of hypotheses, H_1 and H_2, H_3 to H_6, and H_7 and H_8, we consider, in turn, the implications for the three issues discussed previously.

First, we test the impact of pit position on the level of volatility for the next out and nearby contracts with H_1 and H_2. For the entire sample period, both hypotheses are rejected at the 0.001 level of significance. In each case, the coefficient sums (α_2 and $\alpha_2 + \alpha_4$) are significantly negative, indicating that the level of volatility declines for both the nearby and next out contracts when trading occurs in the lead contract pit position (after controlling for volume).

This result supports the notion that the larger population of liquidity providers for the lead contract increases market depth and reduces volatility. An examination of the three subperiods shows that although this phenomenon characterizes behavior during the second and third subperiods (1988–1993 and 1994–1998), there is no significant change in the level of volatility between low-volume and high-volume pit positions during the first subperiod (1983–1987).

Second, we explore the existence of a contemporaneous relation between volume and volatility for each contract, before and after contract redesignation, by examining the volume coefficients (β_i; i = 1–4) and hypotheses H_3 to H_6. Table III indicates that over the entire sample period, all four hypotheses are rejected. The relevant coefficient sum is positive in each case. This behavior is stable over the three subperiods. The coefficient sums involved in H_3 to H_6 are significantly positive in 10 of the 12 cases tested (at the 0.05 level of significance or better). These results suggest a robust positive association between volume and volatility, like that found in most prior empirical research (Karpoff, 1987).

[13]We also repeated this analysis with time and sales data to investigate the analogous relations over higher frequency, 30-min time intervals with robust results (available on request).

TABLE III

GLM Results Relating Total Volume and Volatility Surrounding Redesignation of the Lead Contract

	Full Period: 1983–1998		Subperiod I: 1983–1987		Subperiod II: 1988–1993		Subperiod III: 1994–1998	
Coefficient[a]	Coefficient[b]	t	Coefficient[b]	t	Coefficient[b]	t	Coefficient[b]	t
α_1	0.444	5.6***	−0.031	−0.2	0.541	3.6***	0.290	1.8*
α_2	−0.523	−4.1***	−0.399	−1.5	−1.250	−3.3***	−1.150	−4.1***
α_3	−0.176	−1.6	−0.131	−0.6	0.103	0.4	−0.400	−1.7*
α_4	0.086	0.5	0.507	1.4	−0.276	−0.5	0.316	0.8
β_1	0.120	2.5**	0.675	4.5***	0.044	0.3	0.146	2.0**
β_2	−0.012	−0.2	−0.473	−3.1***	0.222	1.5	0.015	0.2
β_3	0.039	0.7	−0.090	−0.5	−0.088	−0.5	0.075	0.9
β_4	−0.022	−0.4	−0.013	0.1	0.127	0.6	−0.047	−0.5
	$F_{7,1250} = 27.8$ (0.02); $R^2 = 0.13$; $N = 1258$		$F_{7,350} = 17.0$ (0.00); $R^2 = 0.24$; $N = 358$		$F_{7,412} = 4.9$ (0.18); $R^2 = 06$; $N = 420$		$F_{7,472} = 21.5$ (0.00); $R^2 = 0.23$; $N = 480$	

Hypothesis	Coefficient Sum[b]	F	Probability	Coefficient Sum[b]	F	Probability	Coefficient Sum[b]	F	Probability	Coefficient Sum[b]	F	Probability
First Issue: Impact of Contract Redesignation on Level of Volatility												
H_1: $\alpha_2 = 0$	−0.523	16.9	0.000	−0.399	2.2	0.138	−1.250	10.9	0.001	−1.150	17.1	0.000
H_2: $\alpha_2 + \alpha_4$	−0.437	11.6	0.001	0.108	0.2	0.631	−1.526	14.4	0.000	−0.834	8.2	0.004
Second Issue: Existence of Association Between Volume and Volatility												
H_3: $\beta_1 = 0$	0.120	6.0	0.014	0.675	20.3	0.000	0.044	0.1	0.746	0.146	3.9	0.049
H_4: $\beta_1 + \beta_3 = 0$	0.159	36.2	0.000	0.585	39.2	0.000	−0.044	0.1	0.733	0.221	27.7	0.000
H_5: $\beta_1 + \beta_2 = 0$	0.108	74.5	0.000	0.202	37.2	0.000	0.265	14.1	0.000	0.161	58.2	0.000
H_6: $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 0$	0.126	76.4	0.000	0.099	19.9	0.000	0.304	19.6	0.000	0.189	58.2	0.000
Third Issue: Impact of Contract Redesignation on Association Between Volume and Volatility												
H_7: $\beta_2 = 0$	−0.012	0.1	0.812	−0.473	9.5	0.002	0.222	2.1	0.145	0.015	0.0	0.848
H_8: $\beta_2 + \beta_4 = 0$	−0.034	1.3	0.263	−0.485	22.3	0.000	0.348	5.6	0.018	−0.033	0.4	0.505

[a]The GLM estimated here is provided in Table II, Panel A, along with an interpretation of the coefficients and hypotheses H_1 to H_8.
[b]Coefficient estimates for α_1 to α_4 (and their sums involved in H_1 and H_2) are multiplied by 10^4 for ease of exposition. Coefficient estimates for β_1 to β_4 (and their sums involved in H_3 to H_8) are multiplied by 10^8 for ease of exposition. The F test for each hypothesis appears under the heading F, and its approximate marginal significance level appears under the heading *Probability*.
*$p < 0.10$. **$p < 0.05$. ***$p < 0.01$.

Third, we examine whether this positive association between volume and volatility is stable when each contract is traded as lead versus non-lead contract. To do this, we analyze changes in the volume–volatility relation between low-volume and high-volume pit positions for the next out and nearby contracts (H_7 and H_8). Table III shows that during the first subperiod, the coefficient sums involved in H_7 and H_8 (β_2 and $\beta_2 + \beta_4$) are significant and negative. This outcome indicates that during the first subperiod, the additional trading that occurred in the higher volume pit position coincided with a significant reduction in the association between volume and volatility for both contracts. This finding lends support to the liquidity hypothesis. However, this result is not stable over the second and third subperiods. We note the coefficient sum for H_8 during the second subperiod is significant and positive. This subperiod offers the only statistically significant result in our analysis of Equation 1, which suggests that greater volume associated with the lead contract designation exacerbates the association between volume and volatility. All other results are either statistically insignificant or support the alternative hypothesis that greater volume associated with the lead contract designation reduces the level of volatility or the association between volume and volatility. As a result of this instability across the three subperiods, although the coefficient sums involved in H_7 and H_8 are negative over the entire sample period, they are not statistically significant.

GLM Results With Expected and Unexpected Volume

We can replace the single measure of actual volume in Equation 1 with its two components, expected and unexpected volume (EV_{ijt} and UV_{ijt}). Panel B of Table II shows the expanded model and delineates the relevant hypotheses for the three issues discussed previously.

The first issue is addressed by hypotheses H_1 and H_2. As before, these first two hypotheses show whether the level of volatility changes systematically when each contract switches pit positions after redesignation of the lead contract. However, this expanded model now controls for accompanying movements in both expected and unexpected volume.

In this context, we must investigate the second and third issues twice, once to address the association between expected volume and volatility and once for the association between unexpected volume and volatility. We now apply the hypotheses H_3 to H_8 to investigate the second and third issues involving the first component of total volume, EV_{ijt}. Six additional hypotheses, H_9 to H_{14}, provide an analogous assessment of the second and third issues applied to the second component, UV_{ijt}.

Results appear in Table IV Hypotheses H_1 and H_2 yield robust results regarding the first issue with respect to the results of the model incorporating total volume in Table III. That is, H_1 and H_2 indicate the level of volatility tends to be lower for both the nearby and next out contracts when trading occurs in the higher volume pit position (after controlling for both expected and unexpected volume). Again, this phenomenon especially characterizes behavior over the last two subperiods (1988–1993 and 1994–1998). This outcome provides further support for the notion that, because a greater population of liquidity providers and enhanced market depth exist, volatility is lower for the lead contract. Hypotheses H_3 to H_{14} in Table IV address the second and third issues. These tests also yield results that are robust for both EV_{ijt} and UV_{ijt} with respect to the Table III model, which incorporates total volume.

First, we consider the results for expected volume (EV_{ijt}) in hypotheses H_3 to H_8. The coefficient sums in H_3 to H_6 address the second issue for expected volume and are significant and positive in most cases. This outcome indicates a robust positive association between volatility and expected movements in volume, consistent with prior research. Hypotheses H_7 and H_8 address the third issue for expected volume. These hypotheses show that there is a significant decline in the association between expected volume and volatility when trading occurs in the higher volume pit position, but only during the first subperiod (1983–1988). However, this result is once again unstable over the second and third subperiods. The second subperiod shows coefficient sums that are significant and positive, leading to mixed results over the entire sample period.

Next, we consider the analogous results for unexpected volume (UV_{ijt}) in hypotheses H_9 to H_{14}. Once again, the coefficient sums in H_9 to H_{12} are significantly positive in most cases, indicating a robust positive association between volatility and unexpected movements in volume. Finally, hypotheses H_{13} and H_{14} show that there is a significant decline in the association between unexpected volume and volatility when trading occurs as the lead contract, but only in the first subperiod. We again see unstable results over the remaining two subperiods, leading to negative but insignificant results over the entire period.[14]

[14]GLM analysis has also been applied, incorporating only unexpected volume (UV_{ijt}) in the analysis (i.e., excluding EV_{ijt} from the GLM). Results are robust with respect to those provided in Tables III–V and are available on request.

TABLE IV

GLM Results Relating Expected and Unexpected Volume to Volatility Surrounding Redesignation

	Full Period: 1983–1998		*Subperiod I: 1983–1987*		*Subperiod II: 1988–1993*		*Subperiod III: 1994–1998*	
Coefficient[a]	*Coefficient*[b]	*t*	*Coefficient*[b]	*t*	*Coefficient*[b]	*t*	*Coefficient*[b]	*t*
α_1	0.459	5.5***	0.033	−0.2	0.662	4.0***	0.270	1.6*
α_2	−0.528	−4.1***	−0.453	−1.8*	−1.390	−3.6***	−1.130	−4.0***
α_3	−0.177	−1.6	−0.260	−1.2	0.014	0.1	−0.373	−1.5
α_4	0.112	0.6	0.788	2.3**	−0.119	−0.2	0.286	0.7
β_1	0.102	1.7*	0.588	3.8***	−0.123	−0.7	0.166	1.9*
β_2	0.003	0.0	−0.400	−2.5**	0.382	2.1**	−0.004	0.0
β_3	0.075	1.1	0.292	1.5	0.031	0.1	0.067	0.7
β_4	−0.059	−0.8	−0.385	−2.0**	0.003	0.0	−0.039	−0.4
γ_1	0.149	2.1**	0.838	4.6***	0.163	0.1	0.119	1.2
γ_2	0.029	−0.4	−0.610	−3.3***	0.140	0.8	0.039	0.4
γ_3	0.060	0.7	0.274	1.2	−0.294	−1.2	0.137	1.1
γ_4	−0.027	−0.3	−0.240	−1.0	0.302	1.1	−0.113	−0.8
	$F_{11,1246} = 18.2$ (0.00); $R^2 = 0.13$; $N = 1258$		$F_{11,346} = 15.8$ (0.00); $R^2 = 0.31$; $N = 358$		$F_{11,408} = 3.6$ (0.00); $R^2 = 0.06$; $N = 420$		$F_{11,468} = 13.6$ (0.00); $R^2 = 0.22$; $N = 480$	

Hypothesis	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*
First Issue: Impact of Contract Redesignation on Level of Volatility												
H_1: $\alpha_2 = 0$	−0.538	17.2	0.000	−0.453	3.1	0.081	−1.390	13.1	0.000	−1.130	15.9	0.000
H_2: $\alpha_2 + \alpha_4$	−0.426	10.7	0.001	0.335	2.4	0.125	−1.509	11.6	0.001	−0.844	8.3	0.004
Second Issue: Existence of Association Between Expected Volume and Volatility												
H_3: $\beta_1 = 0$	0.102	3.0	0.084	0.588	14.5	0.000	−0.123	0.5	0.467	0.166	3.5	0.061
H_4: $\beta_1 + \beta_3 = 0$	0.176	33.4	0.000	0.881	66.3	0.000	−0.092	0.4	0.554	0.233	24.0	0.000
H_5: $\beta_1 + \beta_2 = 0$	0.104	64.4	0.000	0.188	34.0	0.000	0.259	13.4	0.000	0.162	55.0	0.000
H_6: $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 0$	0.120	64.6	0.000	0.095	11.9	0.001	0.293	13.6	0.000	0.190	56.1	0.000

(Continued)

TABLE IV
(Continued)

Hypothesis	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*
Third Issue: Impact of Contract Redesignation on Association Between Expected Volume and Volatility												
H_7: $\beta_2 = 0$	0.003	0.0	0.966	−0.400	6.4	0.012	0.382	4.4	0.038	−0.004	0.0	0.966
H_8: $\beta_2 + \beta_4 = 0$	−0.056	2.7	0.099	−0.785	49.5	0.000	0.385	4.9	0.027	−0.043	0.6	0.424
Second Issue: Existence of Association Between Unexpected Volume and Volatility												
H_9: $\gamma_1 = 0$	0.149	4.6	0.033	0.838	21.0	0.000	0.163	1.1	0.287	0.119	1.5	0.227
H_{10}: $\gamma_1 + \gamma_3 = 0$	0.209	16.3	0.000	1.112	61.6	0.000	−0.131	0.4	0.515	0.257	10.6	0.001
H_{11}: $\gamma_1 + \gamma_2 = 0$	0.120	57.7	0.000	0.228	43.8	0.000	0.303	16.2	0.000	0.158	40.6	0.000
H_{12}: $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 = 0$	0.153	38.1	0.000	0.262	33.9	0.000	0.311	17.7	0.000	0.182	23.7	0.000
Third Issue: Impact of Contract Redesignation on Association Between Unexpected Volume and Volatility												
H_{13}: $\gamma_2 = 0$	−0.029	0.2	0.684	−0.610	10.8	0.001	0.140	0.7	0.413	0.039	0.1	0.703
H_{14}: $\gamma_2 + \gamma_4 = 0$	−0.056	1.0	0.329	−0.850	32.7	0.000	0.442	4.3	0.040	−0.074	0.7	0.396

[a]The GLM estimated here is provided in Table II, Panel B, along with an interpretation of the coefficients and hypotheses H_1 to H_{14}.
[b]Estimates for α_1 to α_4 (and their sums in H_1 and H_2) are multiplied by 10^4, and estimates for β_1 to β_4 and γ_1 to γ_4 (and their sums in H_3 to H_{14}) are multiplied by 10^8 for ease of exposition. The F test for each hypothesis appears under the heading F, and its approximate marginal significance level appears under the heading *Probability*.
$^*p < 0.10$. $^{**}p < 0.05$. $^{***}p < 0.01$.

GLM Results Incorporating the Persistence in Volatility

We add the lagged value of volatility to the model described previously in Panel B of Table II to investigate the influence of persistence in volatility on the relations that we analyze here. Table V provides the results. The coefficient on lagged volatility is statistically significant, ranging from 0.30 to 0.43 over the different sample periods. The remaining results for the three issues (hypotheses H_1 to H_{14}) are very similar to those presented in Table IV, leading to the same conclusions outlined previously.

Overall, Tables IV and V confirm the results for total volume in Table III. For the first issue, the level of volatility tends to be lower when each contract is traded as the higher volume lead contract, especially during the latter two subperiods. On the second issue, we see a robust significant positive association between volatility and total volume (V_{ijt}) and between volatility and both components of volume (EV_{ijt} and UV_{ijt}) that corroborates most prior research. The third issue yields mixed results that vary across the three subperiods. During the first subperiod (1983–1988), the association between volatility and each component of volume weakens when trading occurs in the higher volume pit position, consistent with the liquidity hypothesis. However, during the second subperiod this outcome is reversed; the association between volatility and each component of volume tends to be strengthened, rather than weakened, when trading occurs as the lead contract. These unstable results across subsamples for the third issue lead to insignificant coefficient sums over the entire sample period.

CONCLUSIONS

This study investigates the behavior of price volatility in the nearby and next out S&P 500 futures contracts on the 10 days surrounding quarterly redesignation of the lead contract. Our results indicate that once we account for the association between volume and volatility, both the nearby and next out contracts experience a lower level of volatility when they are traded as the higher volume lead contract. This outcome is consistent with the hypothesis that a larger population of liquidity providers (i.e., dealers and market makers) attenuates volatility, and vice versa.

The inverse relation that we find between volume and volatility contrasts dramatically with prior results that show volume and volatility are positively correlated. Our evidence, which controls for this contemporaneous correlation, calls into question the merit of any regulatory

TABLE V

GLM Results Relating Expected and Unexpected Volume to Volatility, Including Lagged Volatility

	Full Period: 1983–1998		*Subperiod I: 1983–1987*		*Subperiod II: 1988–1993*		*Subperiod III: 1994–1998*	
Coefficient[a]	*Coefficient*[b]	*t*	*Coefficient*[b]	*t*	*Coefficient*[b]	*t*	*Coefficient*[b]	*t*
α_1	0.338	3.8***	0.016	−0.1	0.381	2.2**	0.245	1.3
α_2	−0.464	−3.6***	−0.471	−1.7*	−1.400	−4.1***	−0.901	−3.1***
α_3	−0.202	−1.8	−0.311	−1.3	0.176	0.7	−0.373	−1.5
α_4	0.220	1.2	0.868	2.4**	−0.637	−1.1	0.306	0.7
β_1	0.003	0.0	0.440	2.6**	−0.122	−0.7	0.044	0.5
β_2	0.079	1.3	−0.277	−1.6	0.387	2.2**	−0.075	0.8
β_3	0.140	2.1**	0.385	1.9*	0.229	1.1	0.123	1.2
β_4	−0.144	−2.1**	−0.477	−2.3**	0.320	−1.4	−0.111	−1.0
γ_1	0.152	2.1**	0.827	4.2***	0.181	1.2	0.110	1.0
γ_2	0.068	−0.9	−0.635	−3.1***	0.143	0.9	−0.001	0.0
γ_3	0.022	0.3	0.246	1.0	−0.025	−0.1	0.063	0.5
γ_4	−0.059	−0.6	−0.161	−0.6	0.051	0.2	0.018	0.1
Lagged volatility	0.376	14.2***	0.305	6.5***	0.428	9.8***	0.326	7.4***
	$F_{12,1117} = 34.7\ (0.00)$; $R^2 = 0.26$;		$F_{12,307} = 18.2\ (0.00)$; $R^2 = 0.39$; $N = 320$		$F_{12,365} = 11.3\ (0.00)$; $R^2 = 0.25$; $N = 378$		$F_{12,419} = 17.0\ (0.00)$; $R^2 = 0.31$; $N = 432$	

Hypothesis	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*	*Coefficient Sum*[b]	*F*	*Probability*
First Issue: Impact of Contract Redesignation on Level of Volatility												
H_1: $\alpha_2 = 0$	−0.464	13.1	0.000	−0.471	3.0	0.083	−1.400	16.5	0.000	−0.901	9.5	0.002
H_2: $\alpha_2 + \alpha_4$	−0.244	3.3	0.068	0.397	2.9	0.088	−0.763	3.1	0.078	−0.595	3.6	0.057
Second Issue: Existence of Association Between Expected Volume and Volatility												
H_3: $\beta_1 = 0$	−0.003	0.0	0.965	0.440	6.5	0.011	−0.122	0.6	0.455	0.044	0.2	0.636
H_4: $\beta_1 + \beta_3 = 0$	0.138	23.3	0.000	0.825	60.8	0.000	0.108	0.6	0.428	0.167	12.9	0.000
H_5: $\beta_1 + \beta_2 = 0$	0.077	39.3	0.000	0.163	26.4	0.000	0.265	18.7	0.000	0.120	30.1	0.000
H_6: $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 0$	0.073	20.0	0.000	0.071	5.1	0.025	0.174	4.9	0.028	0.131	20.1	0.000

Third Issue: Impact of Contract Redesignation on Association Between Expected Volume and Volatility												
H_7: $\beta_2 = 0$	0.079	1.7	0.192	−0.277	2.5	0.113	0.387	4.9	0.027	0.075	0.6	0.430
H_8: $\beta_2 + \beta_4 = 0$	−0.065	4.0	0.046	−0.754	47.0	0.000	0.067	0.2	0.673	−0.036	0.5	0.502
Third Issue: Impact of Contract Redesignation on Association Between Expected Volume and Volatility												
H_9: $\gamma_1 = 0$	0.152	4.3	0.038	0.827	17.3	0.000	0.181	1.5	0.219	0.110	1.0	0.323
H_{10}: $\gamma_1 + \gamma_3 = 0$	0.175	13.1	0.000	1.073	60.2	0.000	0.155	0.8	0.380	0.173	5.1	0.025
H_{11}: $\gamma_1 + \gamma_2 = 0$	0.084	31.9	0.000	0.192	31.8	0.000	0.323	24.6	0.000	0.108	19.1	0.000
H_{12}: $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 = 0$	0.166	40.4	0.000	0.277	34.0	0.000	0.247	11.8	0.001	0.189	19.8	0.000
Third Issue: Impact of Contract Redesignation on Association Between Unexpected Volume and Volatility												
H_{13}: $\gamma_2 = 0$	−0.068	0.8	0.362	−0.636	9.9	0.002	0.143	0.8	0.374	−0.001	0.0	0.992
H_{14}: $\gamma_2 + \gamma_4 = 0$	−0.009	0.0	0.866	−0.797	29.7	0.000	0.091	0.2	0.634	0.016	0.0	0.850

[a]The GLM estimated here is provided in Table II, Panel B, along with an interpretation of the coefficients and hypotheses H_1 to H_{14}.

[b]Estimates for α_1 to α_4 (and their sums in H_1 and H_2) are multiplied by 10^4, and estimates for β_1 to β_4 and γ_1 to γ_4 (and their sums in H_3 to H_{14}) are multiplied by 10^8 for ease of exposition. The F test for each hypothesis appears under the heading F, and its approximate marginal significance level appears under the heading *Probability*.

$^*p < 0.10$. $^{**}p < 0.05$. $^{***}p < 0.01$.

measures that seek to dampen market volatility by artificially curbing trading volume.

Ultimately, this research sparks a new question: Will a regulatory initiative that is intended to reduce volatility affect the risk (and, therefore, cost) associated with market-making activity? If, on balance, these regulatory efforts increase the participation of liquidity providers, the intended outcome (i.e., reduced market volatility) would likely result. However, if the regulatory action interrupts trading activity, as it does in the case of circuit breakers, liquidity providers may be discouraged from participating in the market. In this case, market depth would decline and volatility would likely increase, rather than decrease. Given the critical influence of liquidity providers on market volatility, it would seem that regulators who seek to curb excessive volatility should be particularly sensitive to the impact of their proposed remedies on this group of market participants.

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